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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:)
Naoya Hasegawa et al.)
Serial No. To be Assigned)
Filing Date: Herewith)
For GMR Magnetic Sensing Element)
Provided with Second Free Layer
Extended to Outside of Track Width
and Method for Manufacturing the
Same)

PRELIMINARY AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450
Dear Sir:

Prior to examination of the above-identified application, please amend the application as follows:

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks begin on page 16 of this paper.

Please Amend Claims 1, 4, 8-11, 13-15, 20, 21, 25, 31-37, 40, 41, 43-48 as follows:

(Currently Amended) . 1. A magnetic sensing element comprising a multilayer film including a first antiferromagnetic layer, a pinned magnetic layer, a non-magnetic material layer and a free magnetic layer in that order from the bottom,

wherein the free magnetic layer comprises a first free magnetic layer having a predetermined dimension in the a track-width direction and a second free magnetic layer which is provided on the first free magnetic layer and which has a dimension in the track-width direction larger than that of the first free magnetic layer, a second antiferromagnetic layer for aligning the a magnetization direction of the free magnetic layer in one direction is provided as a layer above the second free magnetic layer, and a pair of electrode layers are provided on both side portions of the multilayer film.

(Original) 2. The magnetic sensing element according to Claim 1, wherein the first free magnetic layer and the second free magnetic layer are provided as an integrated ferromagnetic layer.

(Original) 3. The magnetic sensing element according to Claim 1, wherein a non-magnetic intermediate layer is provided between the first free magnetic layer and the second free magnetic layer.

(Currently Amended) 4. The magnetic sensing element according to Claim 3, wherein the non-magnetic intermediate layer comprises at least one of Ru, Re, Pd, Os, Ir, Cr, Pt, Au, Cu and Rh ~~or an alloy of at least two of them~~.

(Original) 5. The magnetic sensing element according to Claim 4, wherein the non-magnetic intermediate layer comprises Cu.

(Original) 6. The magnetic sensing element according to Claim 1, wherein the dimension in the track-width direction of the first free magnetic layer is 0.18 μm or less.

(Original) 7. The magnetic sensing element according to Claim 6, wherein the dimension in the track-width direction of the first free magnetic layer is 0.15 μm or less.

(Currently Amended) 8. The magnetic sensing element according to Claim 1, wherein [(~~the~~ a difference calculated by subtracting ~~the~~ a film thickness of the free magnetic layer in ~~the~~ a track-width region from ~~the~~ a film thickness of the

free magnetic layer in both side regions of the track-width region) / the film thickness of the free magnetic layer in the track-width region] $\times 100$ (%) is within the range of -80% or more, but less than 0%.

(Currently Amended) 9. The magnetic sensing element according to Claim 1, wherein ~~the~~a film thickness of the second free magnetic layer in both side regions of ~~the~~a track-width region is 10 angstroms or more, but 50 angstroms or less.

(Currently Amended) 10. The magnetic sensing element according to Claim 1, wherein ~~a~~the film thickness of the free magnetic layer in ~~a~~the track-width region is 30 angstroms or more, but 50 angstroms or less.

(Currently Amended) 11. The magnetic sensing element according to Claim 1, wherein the second antiferromagnetic layer is laminated on ~~the~~a track-width region of the second free magnetic layer as well, and ~~the~~a film thickness of the second antiferromagnetic layer on the track-width region is smaller than ~~the~~a thickness of the second antiferromagnetic layer in both side regions located on both sides thereof.

(Original) 12. The magnetic sensing element according to Claim 11, wherein the second antiferromagnetic layer provided on the track-width region of the second free magnetic layer has a non-antiferromagnetic property, and both the side regions of the second antiferromagnetic layer have an antiferromagnetic property.

(Currently Amended) 13. The magnetic sensing element according to Claim 11, wherein one of the second antiferromagnetic layer is provided on the track-width region of the second free magnetic layer so as to have a film thickness of 50 angstroms or less, ~~or~~ and no antiferromagnetic layer is provided on the track-width region of the free magnetic layer.

(Currently Amended) 14. The magnetic sensing element according to Claim 11, wherein ~~the~~ a spacing in the track-width direction between ~~the~~ inner end surfaces of both the side regions of the second antiferromagnetic layer is smaller than or equal to the dimension in the track-width direction of the first free magnetic layer.

(Currently Amended) 15. The magnetic sensing element according to Claim 11, wherein ~~the~~a spacing in the track-width direction between the inner end surfaces of both the side regions of the second antiferromagnetic layer is larger than the dimension in the track-width direction of the first free magnetic layer.

(Original) 16. The magnetic sensing element according to Claim 11, wherein the second antiferromagnetic layer is directly laminated on the second free magnetic layer.

(Original) 17. The magnetic sensing element according to Claim 16, wherein successive film formation of the second antiferromagnetic layer is performed on the second free magnetic layer.

(Original) 18. The magnetic sensing element according to Claim 1, wherein a pair of the second antiferromagnetic layers having a spacing are provided on the second free magnetic layer with a third antiferromagnetic layer therebetween.

(Original) 19. The magnetic sensing element according to Claim 18, wherein a non-magnetic intermediate layer is laminated between the third antiferromagnetic layer and the second antiferromagnetic layer.

(Currently Amended) 20. The magnetic sensing element according to Claim 18, wherein ~~the~~a central portion of the third antiferromagnetic layer has a non-antiferromagnetic property, and both side regions of the third antiferromagnetic layer have an antiferromagnetic property.

(Currently Amended) 21. The magnetic sensing element according to Claim 18, wherein ~~the~~a film thickness of the third antiferromagnetic layer is 5 angstroms or more, but 50 angstroms or less.

(Original) 22. The magnetic sensing element according to Claim 18, wherein successive film formation of the third antiferromagnetic layer is performed on the second free magnetic layer.

(Original) 23. The magnetic sensing element according to Claim 1, wherein a pair of the second antiferromagnetic layers having a spacing in the track-width direction are provided on the second free magnetic layer through a pair

of ferromagnetic layers provided so as to have a spacing in the track-width direction.

(Original) 24. The magnetic sensing element according to Claim 23, wherein successive film formation of the second antiferromagnetic layers is performed on the ferromagnetic layers.

(Currently Amended) 25. The magnetic sensing element according to Claim 23, wherein ~~the~~a total film thickness of ~~the~~a film thickness of the ferromagnetic layer and ~~the~~a film thickness of the second free magnetic layer is smaller than ~~the~~a total film thickness of the film thickness of the first free magnetic layer and ~~the~~a film thickness of the second free magnetic layer.

(Original) 26. The magnetic sensing element according to Claim 23, wherein a non-magnetic intermediate layer is laminated between the second free magnetic layer and the ferromagnetic layer.

(Original) 27. The magnetic sensing element according to Claim 26, wherein the non-magnetic intermediate layer comprises at least one noble metal of Ru, Re, Pd, Os, Ir, Pt, Au, Rh and Cu.

(Original) 28. The magnetic sensing element according to Claim 26, wherein the non-magnetic intermediate layer comprises Cr.

(Original) 29. The magnetic sensing element according to Claim 23, wherein the spacing in the track-width direction between the pair of second antiferromagnetic layers is smaller than or equal to the dimension in the track-width direction of the first free magnetic layer.

(Original) 30. The magnetic sensing element according to Claim 23, wherein the spacing in the track-width direction between the pair of second antiferromagnetic layers is larger than the dimension in the track-width direction of the first free magnetic layer.

(Currently Amended) 31. A method for manufacturing a magnetic sensing element comprising the following steps of:

(a) forming a multilayer film in which a first antiferromagnetic layer, a pinned magnetic layer, a non-magnetic material layer and a first free magnetic layer are laminated on a substrate in that order;

(b) removing both the end portions in the ~~track-width~~ direction of the multilayer film;

(c) forming electrode layers on both sides in the track-width direction of the multilayer film;

(d) laminating a second free magnetic layer having a dimension in the track-width direction larger than that of the first free magnetic layer on the first free magnetic layer; and

(e) forming a second antiferromagnetic layer as a layer above the second free magnetic layer.

(Currently Amended) 32. The method for manufacturing a magnetic sensing element according to Claim 31, wherein a non-magnetic intermediate layer is laminated on the first free magnetic layer in the step (a), and a step of removing at least a part of ~~or all of~~ the non-magnetic intermediate layer is included between the step (c) and the step (d).

(Currently Amended) 33. The method for manufacturing a magnetic sensing element according to Claim 31,

wherein the second free magnetic layer is formed, and successively, the second antiferromagnetic layer is formed in the step (d), and

wherein the step of:

(f) removing the second antiferromagnetic layer on the ~~the~~a track-width region of the free magnetic layer so as to make the ~~the~~a film thickness of the second antiferromagnetic layer on the track-width region smaller than the ~~the~~a film thickness of the second antiferromagnetic layer located on both sides thereof is included in place of the step (e).

(Currently Amended) 34. The method for manufacturing a magnetic sensing element according to Claim 33, wherein ~~the~~a central portion of the second antiferromagnetic layer provided on the track-width region is made to have a non-antiferromagnetic property, and the second antiferromagnetic layer in both side regions of the central portion is made to have an antiferromagnetic property through the step (f).

(Currently Amended) 35. The method for manufacturing a magnetic sensing element according to Claim 33, wherein ~~the~~a film thickness of the central portion of the second antiferromagnetic layer is made to be 50 angstroms or less in the step (f).

(Currently Amended) 36. The method for manufacturing a magnetic sensing element according to Claim 33, wherein ~~the~~a spacing in the track-width direction between ~~the~~inner end surfaces of both the side regions of the second antiferromagnetic layer is made smaller than or equal to the dimension in the track-width direction of the first free magnetic layer in the step (f).

(Currently Amended) 37. The method for manufacturing a magnetic sensing element according to Claim 33, wherein ~~the~~a spacing in the track-width direction between ~~the~~inner end surfaces of both the side regions of the second antiferromagnetic layer is made larger than the dimension in the track-width direction of the first free magnetic layer in the step (f).

(Original) 38. The method for manufacturing a magnetic sensing element according to Claim 31, comprising the steps of:

(g) successively forming a third antiferromagnetic layer on the second free magnetic layer between the step (d) and the step (e); and

(h) forming a pair of the second antiferromagnetic layers having a spacing in the track-width direction on the third antiferromagnetic layer in place of the step (e).

(Original) 39. The method for manufacturing a magnetic sensing element according to Claim 38, wherein the third antiferromagnetic layer is formed to have a film thickness providing a non-antiferromagnetic property in the step (g).

(Currently Amended) 40. The method for manufacturing a magnetic sensing element according to Claim 38, wherein the a film thickness of the third antiferromagnetic layer is made to be 5 angstroms or more, but 50 angstroms or less in the step (g).

(Currently Amended) 41. The method for manufacturing a magnetic sensing element according to Claim 38, comprising the steps of:

(i) laminating a non-magnetic intermediate layer on the third antiferromagnetic layer after the step (g); and

(j) removing at least a part of ~~or all of~~ the non-magnetic intermediate layer, followed by laminating the second antiferromagnetic layer in the step (h).

(Original) 42. The method for manufacturing a magnetic sensing element according to Claim 31, comprising the step of

(k) forming a pair of ferromagnetic layers having a spacing in the track-width direction on the second free magnetic layer and successively

forming a pair of the second antiferromagnetic layers having a spacing in the track-width direction on the pair of ferromagnetic layers in place of the step (e).

(Currently Amended) 43. The method for manufacturing a magnetic sensing element according to Claim 42, wherein ~~the~~a total film thickness of the film thickness of the ferromagnetic layer and ~~the~~a film thickness of the second free magnetic layer is made smaller than ~~the~~a total film thickness of ~~the~~a film thickness of the first free magnetic layer and the film thickness of the second free magnetic layer in the step (k).

(Currently Amended) 44. The method for manufacturing a magnetic sensing element according to Claim 42, wherein a non-magnetic intermediate layer is laminated on the second free magnetic layer, and the ferromagnetic layer is laminated after at leasta part of ~~or all of~~ the non-magnetic intermediate layer is removed in the step (k).

(Currently Amended) 45. The method for manufacturing a magnetic sensing element according to Claim 44, wherein the non-magnetic intermediate layer comprises at least one noble metal of Ru, Re, Pd, Os, Ir, Pt, Au, Rh and Cu in one of the step (i) ~~or~~and in the step (k).

(Currently Amended) 46. The method for manufacturing a magnetic sensing element according to Claim 44, wherein the non-magnetic intermediate layer comprises Cr in one of the step (i) ~~or~~and in the step (k).

(Currently Amended) 47. The method for manufacturing a magnetic sensing element according to Claim 42, wherein the spacing in the track-width direction between the pair of second antiferromagnetic layers is made smaller than or equal to the dimension in the track-width direction of the first free magnetic layer in one of the step (h) ~~or~~and in the step (k).

(Currently Amended) 48. The method for manufacturing a magnetic sensing element according to Claim 42, wherein the spacing in the track-width direction between the pair of second antiferromagnetic layers is made larger than the dimension in the track-width direction of the first free magnetic layer in one of the step (h) ~~or~~and in the step (k).